ENERGY OPTIONS IN SOUTH INDIA WITH REFERENCE TO POWER GENERATION AND LIGNITE DEPOSITS

Phase II Report
November, 1987

Sponsored by

NEYVELI LIGNITE CORPORATION LTD
NEYVELI, TAMIL NADU

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List of reports/documents referred

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1. National Power Plan 1987 - Central Electricity Authority
2. Report of the Energy demand screening group (Aug. 1986) - Planning commission
3. Report on "A Perspective on Energy demand and supply in India in 2004-05" - Advisory Board on Energy (May 1985)
4. Twelfth Electric Power Survey of India (1985) - Central Electricity Authority
5. A brief on Corporate Plan (Jan. 1987) - NLC Ltd
6. Working paper on coal demand for thermal power stations (July 1987) - Department of Coal
7. Coalfield wise Coal Demand and Availability paper - Department of Coal
8. Wind Energy generation data from Department of Non-conventional energy sources
9. Solar radiation over India - A. Mani and S. Rangarajan
10. Irrigation Theory and Practice by A.M. Michael
11. Firewood farming on degraded lands by A.N. Chaturvedi

Executive Summary

Introduction :

The phase-1 report had estimated the relative economics of power generation in the southern region through various available options. It also analysed the availability of coal and lignite for power generation in the region in the terminal years of the 7th and 8th plan periods.

The present study (phase-2) examines the electricity demand projections in the region for the terminal years of 9th and 10th plan periods and the generation options available. It also evaluates the availability of coal, lignite and natural gas for power generation for the 9th and 10th plan periods. The study also covers the economics of power generation through various renewable sources of energy in the region.

Methodology :

The long term forecast is only an indicative forecast which would facilitate identification of resources of power for advance action. These long term forecasts will have to be revised at periodic intervals when the outlines of the perspective development beyond seventh plan become available. The energy demand projections for the southern region has been derived from the report of the "Energy Demand Screening Group" set up by the planning commission in 1986. The supply options for hydro and nuclear have been derived from the National Power Plan 1987. The National Power Plan 1987 has projected an optimal generation expansion plan and a feasible cum desirable generation expansion plan for the period upto 2000. There is a shortfall in hydro and nuclear capacity additions between the two plans and according to the report, this shortfall is likely to made up by increased thermal generation expansion in the feasible plan. This increase is very large and appears to be difficult to achieve. The Department of Coal, in consultation with the Central Electricity Authority, has prepared a paper on the likely thermal generation expansion schemes for the period 1995-2000 and beyond 2000 and also the coal requirements. This data has been used for estimating the thermal contribution.

For our study, we have assumed that the shortfall in hydro and nuclear capacity additions between the optimum and feasible plans of National Power Plan 1987 will materialise during the period 2000-05. For thermal capacity additions, we have assumed two scenarios for 2000-05 :

Scenario A : All new identified thermal generating schemes not linked to any coalfield to be in operation by 2004-05, and

Scenario B : Only 50% of the new identified thermal generating schemes not linked to any coalfield to be in operation by 2004-05.

The demand and availability of coal for each coalfield and the linkages to power stations were obtained from the department of coal. While the demand for utilities is available for the period upto 2000 and also beyond, the demand for other sectors is available only upto the period 1994-95. A 5 per cent annual growth in coal demand for other sectors beyond 1994-95 was assumed for Talcher and Godavari coalfields and also a 5 per cent growth in production plan beyond 2000 was assumed for Talcher Coalfield and the coal balance sheet was prepared. For lignite availability and power generation, the corporate plan of NLC Ltd was used.

Summary findings of the study

1. Electricity demand and Supply :

An electricity balance sheet has been drawn for the years 1999-2000 and 2004-05 for the southern region. In 1999-2000 there is a surplus in energy demand of 2342 kWh but a deficit in peak load demand of 1737 MW. In 2004-05, for scenario A, there is a surplus over energy demand of 11258 MkWh but a deficit of 3561 MW in peak load demand. But for scenario B, in 2004-05, there is a deficit of 11016 MkWh in meeting the energy demand and a deficit in peak load demand of 6193 MW.

2. Coal demand and supply :

The total coal demand for all thermal power stations (existing, on-going and new schemes) in the southern region increases from 30.33 MT in 1994-95 to 36.01 MT in 1999-2000 and to 68.07 MT in 2004-05. Thus there is a very large increase of 32.06 MT in coal requirement for the period 2000-2005 out of which new thermal schemes with a total generating capacity of 8100 MW and requiring 28.16 MT of coal by 2004-05 are not linked to any coalfield.

It was brought out in the phase-1 report that Godavari coalfield which is the major coalfield supplying coal to thermal power stations in the region cannot meet the coal requirements in 1989-90 and 1994-95. The deficit from this coalfield further increases to 5.51 MT in 1999-2000 and 11.42 MT in 2004-05. Thus this coalfield is already linked beyond its capacity.

Talcher coalfield is the only other coalfield which can supply coal to consumers in the southern region and as brought out in phase-I report, has a surplus coal availability of 6.54 MT in 1994-95 and therefore linked to power stations in the southern region from 8th plan onwards. As per the coal balance sheet drawn in this report, it is indicated that this coalfield will have a surplus coal availability of 1.83 MT in 1999-2000 and 0.58 MT in 2004-05, after taking into account all new linkages on this coalfield. Taking both the coalfields together there is a deficit of 3.68 MT in 1999-2000 and 10.84 MT in 2004-05. Over and above this deficit, there is a demand of 28.16 MT from new power schemes in the southern region which are not linked to any coalfield. Therefore, there will be shortfalls in coal supplies to the region in the terminal years of 9th and 10th plan periods, which will adversely affect addition of new thermal generation schemes.

The coal from Godavari Coalfield will be transported to the consumer by rail except for pit-head thermal stations where the movement will be though merry-go-round system of transport. The transport of coal from Talcher can be by all rail means or rail cum sea route. It was brought out in phase-I report that transport of such large quantities of coal during the 8th plan period may be affected due to capacity constraints and operational problems in rail transport and lack of port capacities and large ships for rail cum sea route. The quantities of coal to be transported increase rapidly during 9th and 10th plan periods and therefore movement of coal may prove to be a severe constraint for supplies to the region.

3. Lignite availability from Neyveli

Apart from the new project proposals of NLC presently under the consideration of the government, four potential blocks have been identified for exploitation of lignite deposits at Neyveli. It is projected that the lignite production capacity will increase from 21 MT in 1994-95 to 32 MT in 1999-2000 and 42 MT in 2004-05. This will result in addition to thermal generating capacity at Neyveli by 1500 MW in the 9th plan and 1630 MW in the 10th plan periods. This addition from lignite based thermal schemes will help in meeting the energy demand in 1999-2000 and 2004-05 in the southern region.

4. Natural gas

According to the Advisory Board on Energy's report "A perspective on Energy Demand and Supply in India in 2004-05", the proved reserves of natural gas in the southern region is only 0.125 mcmd in Cauvery offshore basin. Therefore, without a proper assessment of the gas reserves in the region, it will be difficult to assess its contribution in the total supply options. However, if natural gas is available in sufficient quantities and if it is utilised for combined-cycle power generation in the region, it may prove to be economical. It will also greatly relieve the bottleneck in coal transportation.

5. Power generation through renewable sources of energy

The cost of generating power using renewable sources of energy is at present high as compared to conventional means. Also many of these systems are either in R&D stage or in experimental field testing and moreover their potential for the region has not been assessed. Therefore these resources cannot be expected to contribute significantly to meet the growing energy demand in the southern region upto the period 2004-05. However they will be tapped for specific purposes in selected locations for meeting local needs. The economics of power generation from four renewable sources namely solar, wind, biomass and small hydro has been worked out in the report. A summary of the cost of power from different resources is given below :

	System	Cost of power (Rs/kWh)
i)	Small hydro power	1.26
ii)	Dendro thermal power plants	1.53
iii)	Windfarm	2.11
iv)	Bio-mass gasification	1.80
v)	Annual waste gasifier gen-set	1.80
vi)	Gobar gas - diesel gen-set	3.71
vii)	Photovoltaic (Solar)	10.14 to 20.54

Recommendations :

1. Due to the ever growing demand for energy in the region and keeping in view the results of the analysis of various factors involved in the study, it is recommended that the lignite deposits at Neyveli should be exploited fully for additional power generation in the region.

2. A proper assessment of the natural gas reserves in the region should be done so that its contribution in the total power generation can be assessed.

3. Adequate data base and information should be built up on the renewable sources of energy especially wind energy in the region.

CHAPTER - 1

FORECAST OF ELECTRICITY DEMAND FOR THE SOUTHERN REGION (1994-95 to 2004-05)

1.1 Electricity Demand Forecast :

The Twelfth Electric Power Survey (1985) has estimated the load forecasts for all the States in the southern region upto the year 2000. In these exercises, while the trend analysis and end-use method were used for assessing the demand of domestic, commercial, agricultural and other miscellaneous consumers, econometric models correlating 'value added' with 'electricity consumption' were used for estimating the demand in the industrial sector. The power requirements of the southern region as per different studies at the end of various plan periods alongwith corresponding growth rates are shown in the Table below:

Table - 1 : Energy Requirement and Peak Demand Forecasts

	6th Plan (1984-1985)	Growth Rate during 7th Plan (%)	7th Plan (1989-1990)	Growth Rate during 8th Plan (%)	8th Plan (1994-1995)	Growth Rate during 9th Plan (%)	9th Plan (1999-2000)
Energy Requirement (MKWH)							
As per the NPS - 1983	40314	8.3	60032	7.6	86583	7.5	124103
As per the WGP-1984	39542*	11.3	67509	8.6	101842	NA	NA
As per the NPS-1985	39542	11.9	69296	9.6	109505	9.6	173507
Peak Load (MW)							
As per the NPS - 1983	8618*	8.9	13211	8.1	19541	7.6	28224
As per the WGP-1984	6809*	12.3	12175	8.4	18248	NA	NA
As per the NPS-1985	6809*	12.9	12485	9.6	19711	9.6	131202

Actual for 1984-85 (restricted demand)

Source: National Power Plan - 1987 (CEA document)

The Advisory Board on Energy (ABE) and the Planning Commission are now in the process of formulating computer based models for evaluating various demand supply options for making long term development plans for the energy sector. The Planning Commission has set up an "Energy Demand Screening Group" to review the assumptions and methodology of demand forecasts adopted in some recent reports and to project energy demands for the different sectors. The Advisory Board on Energy in its report on "A Perspective on Energy Demand and Supply in India in 2004-05" (May 1985) has analysed the total demand for energy in India in 2004-05 and the supply options for meeting the energy demand. As per this analysis, the regional distribution of energy requirement has been done based on two methods namely i) using the 1982/83 pattern of distribution and assuming that the same proportion would prevail in 2004/05 and ii) using an average of 1960/61 - 1982/83 distribution and assuming that this average proportion would remain in 2004/05. The 1960-61 to 1982-83 electricity consumption regionwise is given in the table below:

Table - 2 : Regional Electricity Consumption (1960-61 to 1982-83) (in bkWh)

Year	Northern	Western	Southern	Eastern + NE	All India
1960-61	2.57	4.61	3.98 (23.5)	5.75	16.91
1965-66	6.10	8.16	6.80 (22.6)	9.03	30.09
1970-71	11.12	13.77	12.34 (25.4)	11.24	48.47
1975-76	16.29	19.24	16.30	14.23	66.06
1982-83	28.34	31.97	26.05 (25.1)	17.44	103.80

Figure in parenthesis indicate the share of southern region in the total energy consumption.

Source : ABE Report on "A Perspective on Energy Demand and Supply in India in 2004-05"

The ABE has also used two scenarios - High and low for demand projection. The electricity demand for the two scenarios using the above assumptions has been projected and is given below :

Table - 3 : Electricity demand in Southern Region in 2004-05.

		Electricity demand in (MkWh)	
1.	Using 1982/83 pattern of distribution	Low	125700
		High	148600
2.	Using an average of 1960/61 to 1982/83	Low	123600
		High	146000

The Energy demand screening group submitted its report to the planning commission in August 1986. The Group has estimated the electricity requirement for the terminal years of 8th, 9th and 10th plan periods for the country. The details are given in Annexure 1.1. Using the same assumptions as taken by ABE, the electricity requirement for the southern region has been worked out. The details are as under:

Table - 4 : Energy Demand in Southern Region

	Electricity Requirement in MkWh		
	1994-95	1999-2000	2004-95
1. Using 1982/83 pattern of distribution	94258	142460	196741
2. Using an average of 1960-61 to 1982-83	92606	139963	193925

Peak Load demand:

The Twelfth Electric Power survey (1985) report has made the forecasts beyond 1989-90 by projecting the overall energy requirements and peak load on the basis of anticipated trends during the seventh plan period. The energy demand screening group has projected the electricity requirements for the terminal years of 8th, 9th and 10th plan as given in Annexure-1.1. This is the latest available report on electricity demand projection. The CEA forecasts the peak demand in the southern region to be 18% of the annual energy demand, and applying this ratio to the energy demand projected in Table 4, the peak load demand is derived as given in the table below :

Table - 5 : Peak load demand in Southern Region

	Peak load demand (MW)		
	1994-95	1999-2000	2004-2005
Using 1982/83, pattern of distribution	16966	25643	35413
Using an average of 1960-61 to 1982-83	16669	25193	34906

CHAPTER - 2

Generation Options

Introduction :

The Southern region is endowed with hydro-electric resources and coal and lignite deposits. The major hydro-electric projects are situated in the west flowing rivers namely Sharavati, Varahi, Periyar etc. and the east flowing rivers namely Krishna, Cauvery, Godavari etc. As per the latest hydro electric survey carried out by the Central Electricity Authority, the total hydro electric potential of these two river systems has been assessed as 11940 MW (at 60% PLF) out of which 41.4% is already developed, 9.5% is under development. Apart from hydro resources, the region has large lignite deposits in Tamil Nadu and the only coal deposits in Andhra Pradesh. Proper balance between thermal and hydro power in the overall generating capacity is an essential pre-requisite for a reliable and efficient power supply system. Therefore, in the recent years, there has been a steady shift towards thermal power generation in the Southern Region.

Installed Capacity at the end of the 7th and 8th Plan periods :

As brought out in the Phase I report, the Southern region had a total installed capacity of 11360.5 MW in 1985-86 which included 6998 MW (61.6%) hydro, 3892.5 MW (34.3%) thermal and 470 MW (4.1%) nuclear. The estimated installed capacity at the end of the 7th Plan (1989-90) would be 15493 MW out of which 8450 MW (54.5%) would be hydro, 6572 MW (42.4) thermal and 470 MW (3.1%) nuclear. At the end of 8th Plan period (1994-95), the total installed capacity is estimated at 22986 MW of which 11244 MW (48.9%) will be hydro, 11272 MW (49%) will be thermal and 470 MW (2.1%) nuclear. While the installed capacity in the region is expected to go up substantially, the hydro electric share would decline from 61.6% in 1985-86 to 54.5% in 1989-90 and 48.9% in 1994-95.

National Power Plan - 1987 :

The Central Electricity Authority in their latest report "National Power Plan - 1987" have analysed the generation capacity expansion options for all regions. They have estimated optimal generation expansion plan additions to installed capacity for a 15-

year period (1985-2000) and also a feasible cum desirable generation expansion plan. The study has taken into account the benefits from sanctioned schemes, CEA cleared schemes and proposed new schemes. The details of these schemes for the southern region are given in the following paragraphs:

Optimal generation expansion plan (1985-2000) :

Benefits from sanctioned schemes :

Sanctioned schemes aggregating to 8892 MW capacity were in various stages of execution in this region. The benefits anticipated from these sanctioned projects during the 7th, 8th and 9th plan period are as under :

Table - 6 : Benefits from sanctioned and on-going projects

Benefits of Generation	Anticipated Benefits during (MW) 7th Plan	8th Plan	9th Plan
Hydro	2116	467	374
Thermal	3100	2600	-
Nuclear	235	-	-
TOTAL	5451	3067	374

Source : National Power Plan - 1987

The details of these schemes are given in Annexure - 2.1.

Benefits from CEA cleared schemes :

There are several projects which have been cleared by the Central Electricity Authority and are pending for government approval. The total capacity of these projects is 1807 MW and the details are as under :

Table - 7 : Benefits from CEA Cleared Schemes (MW)

Type	7th Plan	8th Plan	9th Plan
Hydro	2	1487	-
Thermal	318	-	-
Nuclear	-	-	-
TOTAL	320	1487	-

Source : National Power Plan, 1987

Details of these scheme are given in Annexure - 2.1.

Benefits from New Schemes :

Several new schemes have been identified for bridging the gap between demand and supply during the 8th and 9th plan periods. The total capacity of the new schemes is 6035 MW and these may yield benefits during 8th and 9th plan periods. The details of the schemes are given in Annexure - 2.1. These are based on detailed studies undertaken by CEA to identify new hydro and thermal power plants to meet the anticipated demand. Summary of plant-wise additions to installed capacity is given in Table below :

Table - 8 : Optimal Generation Expansion Plan Additions to Installed Capacity (1985-2000 AD) in Southern Region.

Item	Capacity Additions required during (MW)		
	7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
1. Peak Demand to be met (MW)	12485	19711	31202
2. Details of Capacity additions			
I. **Sanctioned projects (MW)**			
Hydro	2116	467	374
Thermal	3100	2600	-
Nuclear	235	-	-
Sub-Total	5451	3067	374
II. **CEA Cleared Schemes (MW)**			
Hydro	2	1487	-
Thermal	318	-	-
Nuclear	-	-	-
Sub-Total	320	1487	-
III. **New Schemes (MW)***			
Hydro	-	400	5200
Thermal	-	5000	8000
Nuclear	-	1440	1500
Sub-Total	-	6840	14700
IV. **Total Capacity Additions (MW)**			
Hydro	2118	2354	5574
Thermal	3418	7600	8000
Nuclear	235	1440	1500
Sub-Total	5771	11394	15074
V. **Installed Capacity (MW)**			
Hydro	8471 (52.5%)	10825 (39.3%)	16399 (38.5%)
Thermal	7206 (44.6%)	14806 (53.8%)	22806 (53.5%)
Nuclear	470 (2.9%)	1910 (6.9%)	3410 (8.0%)
TOTAL	16147	27541	42615

* Capacity additions by plans from new projects are based on the results of optimisation studies.

Source : National Power Plan 1987 - CEA document (1987)

Feasible cum Desirable Generation Expansion Plan (1985-2000) :

The optimum programme for power development in the region includes several hydro electric and nuclear projects on which advance action has to be initiated in the 7th plan in order to achieve timely benefits. The resources may not permit taking up some of these new projects during the 7th plan period. This will result in shifting of power development plan and the benefits will be derived in subsequent plan periods. In order to achieve the desired level of demand-supply balance and system reliability, it would be essential to take up schemes with shorter gestation period like gas, coal or lignite based thermal power generation in place of hydro projects which have comparitively longer gestation periods. Therefore, CEA in its report National Power Plan 1987, has prepared a feasible cum desirable power programme for 8th and 9th plan periods. A summary of the overall capacity additions envisaged and their category-wise details are given in the table below :

**Table - 9 : Feasible-cum-desirable generation expansion plan
Plan-wise additions to installed capacity (1985-2000)**

SOUTHERN REGION :

I T E M	Capacity additions required (MW)		
	7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
1. Peak Demand to be met (MW)	12485	19711	31202
2. Details of capacity additions :			
i. Sanctioned Project (MW)			
Hydro	2116	467	374
Thermal	3100	2600	-
Nuclear	235	-	-
Sub-Total	**5451**	**3067**	**374**
ii. CEA Cleared Schemes (MW)			
Hydro	2	1487	-
Thermal	318	-	-
Nuclear	320	-	-
Sub-Total	**320**	**1487**	**-**
iii. New Schemes (MW)			
Hydro	-	413	4502
Thermal	-	5730	9600
Nuclear	-	470	970
Sub-Total	**-**	**6613**	**15072**

(Contd /.....)

ITEM		Capacity additions required (MW)		
		7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
iv. Total Capacity Additions (MW)				
Hydro		2118	2367	4876
Thermal		3418	8330	9600
Nuclear		235	470	970
Sub-Total		**5771**	**11167**	**15446**
v. Installed Capacity (MW)				
	(Sixth Plan)			
Hydro	6353 (61.2%)	8471 (52.5%)	10838 (39.7%)	15714 (36.7%)
Thermal	3788 (36.5%)	7206 (44.6%)	15536 (56.9%)	25136 (58.8%)
Nuclear	235 (2.3%)	470 (2.9%)	940 (3.4%)	1910 (4.5%)
Sub-Total	**10376**	**16147**	**27314**	**42760**

Source : National Power Plan 1987 (CEA document)

It can be seen from the table that the share of hydro-electric power declines to 36.7% by the end of the 9th plan period. The fall in hydro is due to the fact that the bulk of hydro-electric power is developed or under development in the region and there is no other option except to install more and more thermal capacity (both coal and lignite) for meeting the anticipated levels of demand. The details of the various schemes are given in the Annexure - 2.2.

Feasible cum Desirable Capacity Additions During the 10th Plan (2000-05)

The CEA in the National Power Plan 1987 have projected the generation capacity additions only upto the year 1999-2000 based on an optimal generation plan and a feasible generation plan. There is a shortfall between the optimum and the feasible plans in respect of hydro and nuclear power projects. According to the report, this shortfall is to be bridged by installing additional thermal generating capacity in the region. The details are as under :

Table – 10 : Difference between Optimum and Feasible power generation expansion plans.

Category		Capacity Additions Required (MW) During 7th Plan	8th Plan	9th Plan
1.	Hydro			
	Optimum Plan	2118	2354	5574
	Feasible Plan	2118	2367	4876
	Shortfall/Surplus	–	(+) 13	698
2.	Thermal			
	Optimum	3418	7600	8000
	Feasible Plan	3418	8330	9600
	Shortfall/Surplus	–	(+) 730	(+) 1600
3.	Nuclear			
	Optimum	235	1440	1500
	Feasible Plan	235	470	970
	Shortfall/Surplus	–	(–) 970	(–) 530

Source : National Power Plan – 1987

However, for drawing an electricity balance sheet for the year 2004-05, we assume that this shortfall in hydro and nuclear power plan will materialise during the period 2000-05.

Thermal Power expansion Plan :

The feasible-cum desirable thermal power expansion plan as given in Table – 9 above is highly optimistic and difficult to achieve. Recently an exercise has been carried out by the department of coal in consultation with CEA and according to this analysis, the thermal power expansion plan for the terminal years of 8th and 9th plans are 5410 MW & 3130 MW respectively. Details are as under :

Table – 11 : Thermal Power Generating Capacity Expansion Plan

Name of Power Station	Capacity Addition (MW) 1994-95	1999-2000
1. Vijayawada (unit 3,4)	420	–
2. Ramagundam	1000	–
3. Mudannur	420	–
4. Manuguru STPS (unit 1,2)	–	1000
5. Raichur (unit 3,4)	420	–
6. Mangalore (unit 1,2)	420	–
7. Kayakulam (unit 1,2)	210	210
8. North Madras (unit 1,2,3)	630	–
9. Tuticorin (unit 4,5)	420	–
10. Mettur Ext.	210	–
11. North Madras (unit 4,5)	–	420
12. Neyveli TPS-2 (4X210) TPS-1 Exp (2X210) TPS-3 (3X500)	1260	1500
TOTAL	5410	3130

Source : Department of coal for coal based TPS NLC Corporate Plan (1987) for lignite TPS.

All these power schemes have been linked to either Godavari or Talcher Coalfield. In addition to these power plants, a number of new hermal power schemes have been identified which will yield benefits beyond 2000. Except Manuguru STPS and lignite TPS, these new schemes have not been linked to any coalfield. The list of these schemes with their capacities are given in the table below :

Table - 12 : List of new thermal power schemes which will yield benefit beyond 2000.

Name of Station	Capacity (MW)
1. Kalingapatnam	1000
2. Vijayawada (unit 5)	500
3. Mudannur (unit 3)	500
4. Manuguru (unit 3,4)	1000
5. Raichur (unit 5,6)	420
6. Mangalore (unit 3,4)	1000
7. New TPS (Kerala)	630
8. Pondicherry	420
9. New TPS (Central)	1000
10. North Madras (unit 6,7)	1000
11. Cuddalore	630
12. Kanyakumari	1000
13. NLC 4th (3x210) & 5th (2x500) TPS	1630
TOTAL	10730

Source : Department of Coal and NLC Corporate Plan.

If all these thermal schemes are in operation by 2005, the thermal capacity addition during the 10th plan period will be 10730 MW. This figure is used for thermal capacity in preparing the electricity balance sheet for 2004-05.

For the year 2004-05, two scenarios are assumed viz.

A: All new identified coal-fired thermal power stations not yet linked to a coalfield with a total capacity of 8100 MW will be in operation in 2004-05 for deriving peak availability and energy availability.

B: Only 50% of new identified coal-fired thermal stations not linked to any coal field (50% of 8100 MW) will be in operation in 2004-05 for deriving peak availability and energy availability.

Electricity Balance Sheet for the Southern Region:

Based on the demand forecasts of the Energy Demand Screening Group report (August 1986) and the hydro, thermal and nuclear power projects likely to be commissioned during 7th, 8th, 9th and 10th plan periods as per the National Power Survey 1987 department of coal document 1987, and our own analysis, an electricity balance sheet is drawn. The following table gives the balance sheet details :

Table - 13 : Electricity Balance Sheet for the Southern region

Sl.No.	Item	1994-95	1999-2000	2004-05 (A)	2004-05 (B)
i)	Installed capacity (MW)	22986	32716	44661	40611
	a) Hydro	11244	15693	16378	16378
	b) Nuclear	470	1910	2440	2440
	c) Thermal	11272	15113	25843	21793
ii)	Peak Availability (MW)	16698	23906	31852	29220
iii)	Energy Availability (MkWh)	100293	144732	207999	185725
iv)	Peak load demand (MW)	19711	25643	35413	35413
v)	Energy Demand (MkWh)	109505	142460	196741	196741
vi)	Deficit in Peak load (MW)	(-)3013	(-)1737	(-)3561	(-)6193
vii)	Surplus/deficit in Energy Demand (MkWh)	(-)9212	(+)2342	(+)11258	(-)11016

A : 8100 MW of additional capacity (as yet unlinked to coalfields) is installed during Tenth Plan.

B : 4050 MW of additional capacity (as yet unlinked to coalfields) is installed during Tenth Plan.

Notes :

1. 1994-95 figures are taken from phase-1 report.
2. Energy demand figures for 1999-2000 and 2004-05 derived from "Energy Demand Screening Group" report (August 1986).
3. Peak load demand derived from energy demand figures in (2) above.
4. Peak P.L.F. of 0.65 assumed for thermal and 0.8 assumed for hydro & nuclear in 1999-2000 and 2004-05.
5. Annual PLF of 0.6278 (5500 hours) assumed for thermal stations and 0.4 (3500 Hrs) assumed for hydro and nuclear power stations in 1999-2000 and 2004-05.
6. For lignite fired power station, a new capacity of 1500 MW (Thermal-III) will be in operation in 1999-2000 and an additional capacity of 1630 MW (630 MW - Thermal-IV and 1000 MW Thermal-V) will be in operation in 2004-05.

CHAPTER - 3

Availability of Coal and Lignite for Power Generation

The gestation period for the development of mines and transport facilities are more often longer than the gestation period for the setting up of thermal power stations. While the first unit of the thermal power station on green site comes up within five years from the date of sanction of the project, it invariably takes more than 5-6 years for the development of an opencast coal mine which period may extend to 8-9 years in case of an underground coal mine. Moreover, the development of a coal mine and associated infrastructure requires large investment. Because of these reasons, the development of a coal mine cannot be undertaken unless the demand forecast in respect of various coal consumers are made available to the Department of Coal. Therefore, the power sector prepares its perspective coal requirements over a long time horizon and supplies it to the Department of Coal and Ministry of Railways to enable them to undertake coordinated development of coal mines and transport infrastructure.

The coal requirements for thermal power stations in the southern region for the terminal years of 8th Plan and 9th Plan was given in the Phase 1 report. The coal requirements depend upon the scheduled generation, quality of coal being supplied and the conditions of power station equipment. In respect of existing thermal power stations, assessment of coal requirements has been made on the basis of average coal consumption in the past period and in respect of new schemes, certain norms were adopted.

The Department of Coal has carried out a fresh analysis (July 1987) on the requirement of coal for thermal power stations for the years upto 2000 and also beyond 2000. The coal requirements for the power stations in the Southern Region are given in the Table below :

Table – 14 : Coal Requirements for the Thermal Power Stations in the Southern Region

Category	Coal Requirements (MT) 1994-95	1999-2000	2004-05
1. Existing schemes	12.61	12.61	12.61
2. On-going schemes	13.98	13.98	13.98
3. New Proposed schemes			
a) Linked to Godavari Coalfield	1.50	5.40	9.30
b) Linked to Talcher Coalfield	2.24	4.02	4.02
c) Not Linked to any coalfield	–	–	28.16
4. Total	30.33	36.01	68.07

Source : Department of Coal paper (July 1987)

A detailed list of the various thermal power schemes with their capacities and coal requirements and linkages are given in the Annexure – 3.1. The new thermal schemes which are not linked to any coalfield have a total capacity of 8100 MW and their ultimate coal requirement is 28.16 MT.

As can be seen from the table, there is a substantial increase in the demand for coal for the thermal power plants from 30.33 MT in 1994-95, to 36.01 MT in 1999-20 and 68.07 MT in 2004-05. The major coalfield which supplies coal to the southern region is the Godavari coalfield in Andhra Pradesh. As brought out in the phase 1 report, the production from this coalfield will not be able to meet the full demand in the terminal years of 7th and 8th plans. Therefore, Talcher coalfield in Orissa State has been linked to supply coal to Southern region during the 8th plan period. It was also found that Talcher is the only coalfield which has the potential and availability of coal in the 8th plan period to supply coal to consumers in the southern region. The coal fieldwise non-coking coal demand and availability for the terminal years of 8th and 9th plans are given in the Annexure – 3.2. The table below gives the summarised position in respect of coalfields which supply coal to southern region.

Table – 15 : Coal Demand and Availability in Coalfields Supplying Coal to Southern Region Consumers (Fig in M.T)

Coalfield	1994-1995 Demand	Avail.	Deficit/ Surplus	1999-2000 Dem.	Av.	Defi./ Sur.	2000-2005 Dem.	Av.	Defi./ Surplus
Godavari	35.54	32.00	-3.54	43.51	38.00	-5.51	51.42	40.00	-11.42
Talcher	17.60	24.14	+6.54	29.05	30.84	+1.85	37.97	38.85	+ 0.58

Apart from these two coalfields, Raniganj coalfield supplies about 2.27 MT/a to Tuticorin power station (units 1,2,3) and is projected to supply the same amount in 1999-2000 and beyond. The new units in Tuticorin power stations are linked to Talcher coalfield due to non availability of additional coal from Raniganj coalfield.

Godavari Coalfield :

As per the analysis carried out by the Department of Coal, the production capacity of this coalfield has been estimated at 38 MT in 1999-2000 and 40 MT in 2004-05 which is taken as the ultimate production capacity. Because of the increased thermal generation expansion plans drawn by CEA for the southern region, the demand on this coalfield is increasing rapidly. A balance sheet on coal demand and availability has been prepared and is given in the table below:

Table - 16 : Godavari Coalfield Coal Balance Sheet for 1994-95, 1999-2000 and 2004-05 (Fig. in M.T.)

		1994-95	1999-2000	2004-05
Demand				
	Power (Utilities)			
	- Existing Units	11.84	11.84	11.84
	- Sanctioned schemes	11.41	11.41	11.41
	-New proposed schemes	1.50	6.96	12.36
	Power (Captive)	0.74	0.74	0.74
	Power (Total)	25.49	30.95	36.35
	Non-Power Sector	10.05	12.56	15.07
	Total Demand	35.54	43.51	51.42
Total Production Plan		32.00	38.00	40.00
Deficit		(-) 3.54	(-) 5.51	(-) 11.42

Note : 1. Requirements of coal for captive power stations is assumed at the same level as in 1994-95;

2. For non-power sector, an average annual growth of 5% is assumed over 1994-95 demand;

3. Production capacity for 2004-05 is assumed as 40 MT.

Source : Department of Coal.

The detailed linkages to power houses from this coalfield is given in Annexure - 3.1. The production plan details are given in Annexure - 3.3.

Talcher Coalfield :

The potential of this coalfield has already been covered in the Phase 1 report. As per the analysis, there is a surplus coal availability of 6.54 MT in 1994-95 which can be supplied to the consumers in the Southern Region. The constraints in achieving the production level in 1994-95 were also covered. Since Talcher coalfield is a potential coalfield for supply of coal to power stations in the Southern Region, more and more power stations are being linked to this coalfield. An analysis has been carried out and the balance sheet on coal demand and availability has been prepared and is given in the following table :

Table -17 : Talcher Coalfield Coal Balance Sheet for 1994-95, 1999-2000 and 2004-05 (Fig. in M.T.)

	1994-95	1999-2000	2004-05
Demand			
Power (Utilities)			
- Existing Units	1.61	1.61	1.61
- Sanctioned schemes	3.35	3.35	3.35
-New proposed schemes	4.57	15.19	22.37
Power (Captive)	4.93	4.93	4.93
Power (Total)	14.46	25.08	32.26
Non-Power Sector	3.14	3.97	5.71
Total Demand	17.60	29.05	37.97
Total Production Plan	24.14	30.84	38.55
Surplus/Deficit	(+) 6.54	(+) 1.83	(+) 0.58

Assumptions :

1. Coal requirement for captive power station is kept at the same level as in 1994-95;
2. For non-power sector, an average annual growth of 5% is taken over 1994-95 demand;
3. Production plan for the period 2000-05 is assumed to grow at a rate of 5% annually.

Source : Department of Coal.

The detailed linkage of power stations to this coalfield is given in Annexure-3.1. The production plan details are given in Annexure - 3.4.

Lignite from Neyveli :

As per the corporate plan document (Jan 1987) of NLC Ltd., the new mine schemes awaiting government clearance are i) Mine I expansion from 6.5 MT/a to 10.5 MT/a which may produce lignite during 8th plan period to feed an additional thermal generating capacity of 420 MW and ii) Mine III with a capacity of 11 MT/a which may start production in 9th plan and is linked a thermal generating capacity of 1500 MW. Apart from these new schemes, four blocks have been identified for exploitation which can be worked by establishing three new mines. The details are as under :

Table - 18 : Lignite reserves in new blocks at Neyveli

Mine	Geol.Reserves M.T.	Mineable Reserves M.T.	Production capacity M.T./a
Mine IV	154	139	4.0
Mine V	375	338	10.0
Mine VI	274	247	6.5
Total	803	724	20.5

Source : NLC Corporate Plan (Jan. 1987)

Thus the establishment of three new mines could serve generating units of about 3130 MW aggregate capacity if power alone is to be produced. The details of estimated total power generating capacity and the lignite requirements upto the year 2004-05 are given in the table below :

Table-19 : Thermal Power capacity and lignite capacity in Neyveli

TPS	Capacity (MW)	Lignite Requirement (MT) 1994-95	1999-2000	2004-05	Status	Linkage
1. TPS-I	600	6.0	6.0	6.0	Existing	Mine 1
2. TPS-II	1470	10.5	10.5	10.5	On-going	Mine 2
3. TPS-I Ext.	420	4.0	4.0	4.0	New	Mine 1
4. TPS-III	1500	-	11.0	11.0	New	Mine 3
5. TPS-IV	630	-	-	4.0	New	Mine 4
6. TPS-V (2x500)	1000	-	-	6.5	New	Mine 5
	5620	20.5	31.5	42.0		

Source: NLC Corporate Plant (Jan. 1987) and National Power Plan 1987.

TPS-V (3rd unit - 500 MW) and TPS-VI (1000 MW) may be commissioned beyond 2005.

The Geological Survey of India have also identified potential deposits of lignite in Bahur area (partly in Tamil Nadu and partly in Pondicherry) with ae also identified potential deposits of lignite in Bahur area (partly in Tamil Nadu and partly in Pondicherry) with an estimated reserves of 250 MT. This area could be developed into a mine of 6 MT/a capacity. GSI is carrying out exploration activities in Trichy district where sizeable reserves of lignite are indicated.

Natural Gas from Cauvery and Godavari Basins :

ABE's report, "A Perspective on Energy Demand and Supply in 2004-05", has not indicated any gas based generating capacity in the Southern region by 2004-05 because of very low level of proved gas reserves in the region. According to the Oil and Natural Gas Commission, production potential of natural gas based on prognosticated reserves in the southern region is 26.42 million cubic metres per day. (Cauvery offshore - 7.42, Cauvery on-shore - 2.00, Krishna-Godavari on-shore - 17.0). However, based on proved reserves, the production potential is 0.125 mcmd (in Cauvery offshore) only. If natural gas will be available in sufficient quantities in the southern region, the gas can be utilised in combined-cycle power generation. This will greatly relieve the bottleneck in coal transportation. It will also be economical and will lead to an improvement in the reliability and quality of power supply. However, without a proper assessment of the proved resources of natural gas in the region, it will be difficult to assess its contribution in the total supply option.

CHAPTER - 4

Electric power generation through renewable sources of energy

Several technologies are now either available or strongly feasible for electric power generation through renewable energy sources. Some of these are as follows :

1. **Direct Solar Systems.**
   - solar photovoltaic systems
   - solar central receiver systems
   - solar dish-stirling systems
   - solar parabolic trough systems
   - solar ponds
2. **Bio-mass based systems**
   - Dendrothermal power stations
   - Wood gasifier systems
   - Direct combustion of briquetted agrowastes
   - gasification of briquetted agrowastes
   - biogas driven generators
3. **Indirect solar systems**
   - Wind electric generators
   - Small hydropower
   - Ocean thermal electric conversion systems
4. **Municipal and domestic refuse in Urban cities**

The cost of generating power using there resources is at present high as compared to thermal power stations and nuclear power stations. Also many of these systems are either in the R&D stage or in experimental/field testing and therefore, it is expected that their costs will reduce somewhat in the future. The costs of power generation from small hydro stations can compare favourably to that from conventional systems. Moreover the contribution from these sources is so low that they cannot be an alternative to meet the growing needs of the southern region. However, the load specific and location specific impact of renewable technologies is substantial and has to be tapped. The economics of power generation from some of the systems has been attempted in this chapter.

Energy Plantation for fuelwood :

According to the Fuelwood Study Committee, 1 ha of land can sustain a power generating capacity of about 3.75 kW. This assumes among other things, a P.L.F. of 60% and a mean annual increament (MAI) of wood of 16 tonnes/ha/year. According to the report of the working group on Non-conventional Energy sources for the Seventh Plan, 1 ha of land can generate 3 KW of power. According to another study the MAI figures are generally around 10 tonnes/ha/year only and at this level 1 ha of land can sustain a generating capacity of 1.875 KW. However, there are basic issues that have to be addressed like the availability of land while planning for plantation projects designed to generate power. Also, there may not be much wasteland available for fuel wood plantation in the Southern region, especially meant for power generation. Further these projects should be viewed as decentralised small projects, and therefore, they cannot be expected to contribute significantly in meeting the energy demand in the region.

Solar Energy Prospects :

The use of solar photovoltaics can be promoted for the electrification of remote villages. The Rural Electrification Corporation has identified some 90,000 such villages (on an all India basis) to which it would be very expensive to extend grid electricity. In some of these villages solar photovoltaics would be a feasible and economic option. According to ABE, for each village the minimum average requirement of electricity is i) 0.3 KW for street lighting; ii) 0.3 kW for community health visit; iii) 0.1 KW for community radio and TV; iv) 0.3 kW - 1.5 kW for drinking water systems and v) upto 1.5 KW for additional irrigation pumps etc.

According to a TERI study, the annual and monthly solar energy resources over the different regions may be summarised as follows:

During the whole year, gross solar radiation (GSR) measures over 2000 kWh/m^2 over Rajasthan and Gujarat in the West; is less than 1700 kWh/m^2 over Bihar, West Bengal and Assam in the East; and is between 1700 and 2000 kWh/m^2 over the remaining parts of the country. During January to May, GSR is around 180 kWh/m^2 in the Southern Region. The economics of solar energy is given later in this chapter.

Wind Energy Prospects :

Energy from wind is used either for pumping water or for generating electricity. A water pumping windmill differs considerably from wind electric generation in terms of size, structure and design and therefore, wind data requirements for the two devices differ. The current knowledge on wind velocity regimes in the different regions is very inadequate. The data is recorded usually at a height of less than 5 m. In most places, windspeeds increase with heights above ground level. As per the "Wind Energy Data for India", (a publication from the DNES), Gujarat is the most windy state in India, in particular the coastal stretch between Mandvi and Kandla. This stretch of about 100 km has an estimated wind potential of 5000 MW, as the mean annual wind speeds are above 22 km/hour. In the Southern region, Tuticorin has an estimated wind potential of about 520 kWh/m^2 per annum, at Coimbatore, the annual wind potential is 650 kWh/m^2 and at Kanyakumari, it is 610 kWh/m^2. The total wind potential in the region has not been estimated. It is possible to divide areas with wind potential into low wind and high wind areas. The high wind areas are those that have mean annual wind speeds higher than 15 km/hour and can be used for generating electricity; while low wind areas can be conveniently used for water pumping. Planning for wind energy application should also keep in view the seasonal variations. An area where wind power can be utilised is agriculture - to meet the energy requirements for irrigation, harvesting, drying and processing of the product. The use of stand-alone wind energy conversion systems in remote villages can be used for rural electrification. Electricity generated from wind farms can be connected to grid systems and may be viable as established by DNES. Therefore, efforts have to be made to establish proper data base and search for windy sites. According to ABE's report, mean wind speeds exceeding 22 km/hr would make the economics of wind generated electricity very attractive.

Economics of Power Generation from Renewables

The economics of electricity generation from four renewables is examined viz. wind, solar radiation, biomass and small hydropower. In each of these cases, the economics is dependent on the size of the plant and the availability of raw material. The cost of electricity generation is computed by the following methodology :

$$C_E = C_A/G_A$$

where $C_A = (CRF)(C_c) + C_o + C_f$,

and $CRF = i(1+i)^L/[(1+i)^L - 1]$.

C_E is the cost of electricity, C_A is total annual costs, G_A is net annual generation, CRF is capital recovery factor, C_c is capital cost, C_o is annual operating and maintainence cost (including all supplies, except fuel), C_F is annual fuel cost, i is effective rate of return, and L is life of plant. The rate of return is taken as 12%.

Wind Energy

Wind energy is best exploited by setting up "wind farms" which are a conglomeration of a large number of wind generators at a suitable site. DNES has set up six wind farms - one each at Mandvi and Okha in Gujarat, Deogad in Maharashtra, and Puri in Orissa, and two at Tuticorin in Tamil Nadu. The energy generated from these farms is given in Table 20.

Table - 20 : Wind Energy Generation Data from DNES Wind Farms

Site	Capacity (kW)	Date Operational	Energy Generated kWh	Till	Days Operational	Estimated Annual Generation (kWh/kW)
Mandvi	1100	16-1-86	2,476,165	30-6-87	531	1547.3
Tuticorin I	550	18-1-86	1,227,538	30-6-87	529	1540.0
Okha	550	8-3-86	1,194,230	31-5-87	450	1761.8
Deogad	550	27-4-86	552,254	30-6-87	430	852.7
Puri	550	30-4-86	455,973	30-6-87	427	709.1
Turicorin II	330	21-11-86	312,951	30-6-87	222	1560.6

Source : Department of Non-Conventional Energy Sources (Personal Communication).

Based on information available, the annualized cost of generating electricity is estimated for a site similar to Tuticorin. The annual electricity generation norm is assumed to be 1550 kWh/kW. Following cost and operating data are obtained from DNES for a 550 kW wind farm:

C_c = Rs. 9.25 million,

C_o = Rs. 0.56 million, and

L = 20 years.

For i = 12%, and L = 20 years, CRF is 0.134. The total electricity generated is 0.853 MkWh; annual cost is Rs. 1.80 million, and therefore, cost of power is Rs. 2.11/kWh.

Solar Radiation (Photovoltaics)

Photovoltaic (PV) panels can be used to meet the power requirements (for lighting and/or agricultural equipments - principally pumpsets) for locations where transmission lines from the regional/local grid have not been laid. The economics of PVs for two applications are discussed : (a) for irrigation pumping, and (b) for street lighting and community center. Based on data supplied by ARCO Solar Inc. of USA, the cost per watt of a PV module is taken as Rs. 111, and the cost of storage as Rs.2,000/kWh. The life of the panel is 20 years, while battery life is taken as 7 years. The (present value) cost of replacing the battery after the 7th and the 14th years raise battery cost to Rs.3,314/kWh. O & M costs are assumed to be 2% of total capital cost, CRF is 0.134.

Irrigation Pumping :

In order to size the PV panel, it is necessary to estimate the power requirement for pumping. Also the power output from the panels varies according to solar radiation, and therefore the sizing will have to be done for the period in which the ratio of the solar radiation to water requirement is minimum. Table - 21 lists the water requirement for a typical cropping pattern in South India (78.9% of irrigated area under rice, 4.4% under sugarcane, 4.1% under oilseeds, 2.8% under ragi, 1.4% under bajra, 1.2% under maize and the remaining 7.2% under other crops), and the mean daily solar radiation over Bangalore (which is roughly mid-latitude for South India).

Table -21 : Monthly Irrigation Water Requirement and Global Solar Radiation for South India

Month	Monthly Water* Requirement (m^3/ha. month)	Global Solar** Radiation (kWh/m^2 . day)
January	2039.6	5.483
February	39.0	6.172
March	98.0	6.257
April	49.0	6.568
May	-	6.054
June	2001.6	4.897
July	3895.2	4.182
August	1893.6	4.608
September	1893.6	4.803
October	3865.2	4.936
November	2217.1	5.019
December	2152.6	4.949

* This has been calculated on the basis of the requirement of water by different crops as given in Irrigation Theory and Practice by A.M. Michael (Vikas Publishing House, New Delhi, 1985), and the cropping pattern described in the text.

** Solar Radiation over India by A. Mani and S. Rangarajan (Allied Publishers, New Delhi, 1982).

From Table 21, it is clear that July will be the critical month, and the PV panel will have to be sized for July characteristics. The latitude for Bangalore is 12.5^{o} N, and the declination for July is 20^{o}: the solar altitude is therefore 82.5^{o}. The panel is mounted at 11^{o} to the horizontal, and the medium daily global solar radiation in July becomes 5.17 kWh/m^2 day. The total head through which water has to be lifted is assumed as 10m, and therefore, the total hydraulic head required during July is 106.1 kWh/ha. The efficiency of PV's is taken to be 9.2%, and that of the pump as 26% and the required electricity generation is, therefore, 408.1 kWh/month, or 13.16 kWh/day. This implies a panel area of 27.7 m^2, and a peak watt rating of 2546 or 2550 W. The annual generation is 2122 kWh. Consequently,

C_C = (2550) (111) = Rs. 283050,

C_O = Rs. 5661,

C_A = Rs. 43589, and

C_E = Rs. 20.54.

Street Lighting, Community TV and Health Center :

For analytical purposes, it is assumed that a PV panel will provide power to a cluster of six villages, each with twenty families owning 1 ha each. The power requirement is calculated based on the following assumptions : (i) Each village has six street lights, each with a 100 W bulb that remains switched on 10 hours/day, (ii) each village has a community TV set with a load of 200 W, and which works for 5 hours/day, and (iii) the cluster has one primary health center with a continuous load of 200 W. The total electricity demand is therefore, 16.8 kWh/day, or 6132 kWh/year.

From the global solar radiation data given in Table - 21, the critical month for sizing the PV array area will be July when the median daily GSR is minimum - 4.182 kWh/m^2. Under these conditions, a PV array of 35 m^2 (at 11^o to the horizontal), i.e. having a 3220 peak-watt rating, is adequate to meet the daily energy requirements. Since the majority of the demand (about 14 kWh/day) is to be met during non-sunshine hours, it becomes necessary to use a storage battery as well. The costs are :

$$C_c = (3220)\ (111) + (14)\ (3314) = \text{Rs. } 403816$$

$$C_o = \text{Rs. } 8076$$

$$C_A = 54111 + 8076 = \text{Rs. } 62187$$

The power cost is, therefore, Rs. 10.14/kWh.

If the PV panel is to meet the total demands of the cluster, then the peak daily requirement is :

Sunshine Hours :	Irrigation	13.16 x 20 x 6	=	1579.2 kWh
	Health Center	0.2 x 14	=	2.8 kWh
Non sunshine Hours :	Street lights	0.1x10x6x20	=	120.0 kWh
	TV	0.2 x 5	=	1.0 kWh
	Health Center	0.2 x 10	=	2.0 kWh
		TOTAL		1704.0 kWh

A panel area of 3,583 m^2 is required to supply 1704 kWh/day and a storage battery of 122 kWh is required. Costing is done for a 3,600 m^2 panel (331.2 kW peak rating) and a 125 kWh storage battery.

C_c = (331.2 × 111000) + (125 × 3314) = Rs. 37.18 million

C_A = (0.134 + 0.02) (37.18) = Rs. 5.73 million

Annual generation requirement is :

Irrigation : 2122 × 20 × 6 kWh = 254640 kWh
Health Center : 0.2 × 24 × 365 kWh = 1752 kWh
TV : 0.2 × 5 × 365 kWh = 365 kWh
Street Lights : 0.1×10×6×20×365 kWh = 43800 kWh

G_E = 300557 kWh

Hence, C_E = Rs. 19.06/kWh.

Biomass

Organic matter (woodwaste, animal waste etc.) has some calorific value which can be utilized to generate electricity. There are principally two technology options : the first is to directly burn the biomass, and the other is to gasify it into a hydrogen/methane rich gas which is then burnt. Two biomass feedstock will be considered here : wood and animal dung. Dung production in the four states of South India was 22.2 MT in 1977 (Prem Narain et al., "A study on Availability and Consumption of Bio-Energy" in Proceedings of First Convention of the Bio-Energy Society, New Delhi, 1984).

Direct Combustion of Biomass

Wood has a calorific value of about 18.5 MJ/kg (4400 kcal/kg), and can be easily burnt. Such systems, referred to as dendrothermal systems, have overall conversion efficiency of about 15% (heat rate of 24 MJ/kWh, or 5740 kcal/kWh). The woodwaste produced as a result of wood processing can be used as feedstock. It is estimated that 0.2 cu.m of lops and tops, 0.1 cu.m of bark, and 0.08 cu.m of sawdust is produced per cu.m of logs produced. Alternatively, degraded soils may be planted with rapidly growing tree species which could be selectively harvested to provide wood for the dendrothermal plant. It is estimated that a 82 ha plantation can perpetually provide enough wood to power a 100 kW dendrothermal power plant. The major difficulty in calculating the power cost from a dendrothermal plant is to assign a cost to wood. In the case of woodwastes, a collection cost of Rs. 1/kg is often assumed. The costs of energy plantation are included in the dendrothermal project. Costs are shown in Table – 22.

Table - 22 : Cost of a 1 kW Dendothermal Power Plant

Installed Capacity	1 kW
PLF	50%
Annual generation : Gross	4380 kWh
Net	3942 kWh
Heat rate	5740 kcal/kWh
Wood calorific value	4400 kcal/kg
Annual wood consumption	5713.9 kg
Annual Plantation Wood Production	7000 kg/ha *
Plantation Area Required	0.816 ha
Capital Investment	
Power Plant @ Rs 15,000/kW	Rs. 15,000
Plantation @ Rs. 10,000/ha*	Rs. 8,160
	23,160
Annual Costs	
Annualized Capital Cost (CRF=0.134)	Rs. 3103.44
O&M Costs : Power Plant @ 10% of capital cost	Rs. 1500.00
Plantation @ Rs.0.25/kg of wood produced	Rs. 1428.48
	Rs. 6031.92
Electricity Cost	Rs. 1.53/kWh

Source : Firewood Farming on Degraded Lands by A.N. Chaturvedi, U.P. Forest Bulletin No. 50, 1985.

Gasification of Biomass

Wood or organic wastes can be gasified to produce a $CO/H_2/N_2$ gas having typically a calorific value of about 1000 kcal/m^3. This gas can be directly used in IC engines as an admixture of diesel or petrol to produce electricity. Diesel replacement can vary from 40 to 70% depending on the gas composition. Long term data for gasifier coupled diesel gen sets is not available, and hence some assumptions have to be made regarding their performance. Two cases are examined here : Wood gasifiers and animal waste gasifiers.

Wood Gasifier - Gen Sets : Gas calorific value is 1100 kcal/m^3. Typically, gen sets operated in the dual fuel mode (diesel-gas mixture) seem to result in derating of capacity by about 25% (M.B. Durgaprasad et al., "Field Implementation of Gasifier Systems for Irrigation", Paper presented at the Third USAID/GOI Workshop on Alternative Energy Sources, New Delhi, 1985). At 70% diesel replacement, the specific diesel consumption decreases from 0.40 l/kWh (14.9 MJ/kWh) to 0.12 l/kWh. The makeup gas specific consumption is about 3.5 m^3/kWh. The overall heat rate thus increases to 20.6 MJ/kWh. The costs are given in Table - 23. Electricity cost works out to Rs. 1.80/kWh (in comparision, the cost of power from an all diesel gen set is Rs. 1.90/kWh).

Animal Waste Gasifier - Gen Sets : Gas calorific value is about 1100 kcal/m^3, and the gen set operting characteristics are the same as that with wood gas. Dung conversion rate is 0.03 m^3 of gas per kg of dung. Dung cost is taken as Rs. 0.02/kg. Table - 24 lists the costs.

Table - 23 : Cost of 1 kW Diesel - Wood Gas Power Plant

Capacity	1 kW
Derated Capacity	0.75 kW
PLF	50%
Annual Generation : Gross Net	3285 kWh 2956.5 kWh
Diesel Consumption @ 0.12 l/kWh	394.2 l
Wood Gas consumption @ 3.5 m^3/kWh	11497.4 m^3
Gasifier Capacity	0.838 kW
Wood requirement @ 0.4 kg/m^3 gas	4599 kg
Plantation Area @ 7000 kg wood/ha	0.657 ha
Capital Costs	
Plantation @ Rs. 10,000/ha	6,570.00
Gen Set @ Rs. 4,500/kW	4,500.00
Gasifier @ Rs. 3,000/kW	2,514.00
	Rs. 13,584.00
Annual Costs	
Annualized Capital Cost	Rs. 1,820.26
O&M Costs : Gen Set & Gasifier 10% of capital Cost	Rs. 701.40
Plantation @ Rs.0.25/kg Wood	Rs. 1,149.75
Lube Oil cost @ Rs.0.0051/kWh	Rs. 284.92
Diesel Oil cost @ Rs.3.5/l	Rs. 1,379.70
	Rs. 5,336.03
Electricity Cost = Rs. 1.80/kWh	

Table - 24 : Cost of Power from Gobar Gas - Diesel Gen Set

Capacity	1 kW
Derated Capacity	0.75 kW
PLF	50%
Anuual Generation : Gross Net	3285 kWh 2956.5 kWh
Diesel Consumption @ 0.12 l/kWh	394.2 l
Gobar Gas consumption @ 3.5 m^3/kWh	11497.5 m^3
Gasifier Capacity	0.838 kW
Gobar Gas consumption @ 33.3 kg/m^3 gas	382866.7 kg
Capital Costs	
Gen Set @ Rs. 4,500/kW	Rs. 4,500
Gasifier @ R. 3,000/kW	Rs. 2,514
	Rs. 7,014
Annual Costs	
Annualized capital cost	Rs. 939.88
O&M Costs : Gen set & Gasifier @ 10% of Capital cost	Rs. 701.40
Lube Oil Cost @ 0.0051/kWh	Rs. 284.92
Diesel Oil cost @ Rs.3.5/l	Rs. 1,379.70
Gobar Cost @ Rs.0.02/kg	Rs. 7,657.34
	Rs.10,963.24

Electricity Cost : Rs. 3.71/kWh.

Mini Hydropower

In India, the potential for mini hydropower plants is of the order of 16,000 MW, of which about one-seventh is in Southern region. Mini hydro projects can be broadly classified into two types : (i) utilizing small discharges, and (ii) utilizing large discharges but under low head. Factors which influence the cost of small hydro-projects are head available, discharge rate, and type of generator used. Further, the first type of small hydropower projects (utilizing small discharges) are normally located in remote and hilly areas where infrastructural facilities are limited leading to a further increase in cost. The capital cost of the these first type small hydro projects ranges anywhere between Rs.13,600/kW to Rs.38,350/kW (depending on length of water channel/tunnel required), whereas the cost of the second type projects is between Rs. 6,400/kW to Rs. 10,500/kW.

The second type project (utilizing small heads with large discharges such as small rivers, irrigation outlets, canal falls, dam toes etc.) are more likely in South India which already has a large irrigation system in Karnataka, Andhra Pradesh and Kerala. Some first type hydro projects are possible in the Western Ghats and Nilgiris. It is assumed here that the capital cost is Rs. 20,000/kW. Other cost data are based on mini hydropower projects sanctioned by CEA before 1982. Table - 25 lists the costs, and computes the cost of power as Rs. 1.26/kWh.

Table - 25 : Cost of Power from a 1 kW Small Hydropower Project

Capital Cost		Rs. 20,000
Annual Generation	: Gross	Rs. 2,000 kWh
	Net	Rs. 1,990 kWh
O&M Cost (0.5% of capital cost)		Rs. 100
CRF (at 12% discount rate and 50 years project life)		Rs. 0.120
Annualized Capital Cost		Rs. 2,508
Total Annual Cost		Rs. 2,608
Power Cost		Rs. 1.26/kWh

A summary of the cost of power generation from different renewable energy technologies is given in the table below :

Table - 26 : Cost of Power from Renewables

Sl. No	System	Cost of power (Re/kWh)
i)	Small hydro plants	1.26
ii)	Dendothermal power plants	1.53
iii)	Windfarm	2.11
iv)	Biomass gasification	1.30
v)	Animal waste - gasifier gen set	1.80
vi)	Photovoltaic	10.14 to 20.54
vii)	Gobar gas - diesel gen set	3.71

CHAPTER - 5

Conclusion and Recommendations

Phase-I Study (Upto 1994-95)

1. The phase-1 report had brought out the relative economics of thermal power generation at a site near Neyveli through different options like coal from Talcher coalfield, imported coal from Australia and lignite from Neyveli. It was observed that :

i) the economic cost of power generation from lignite is about the same as the cost of power generation using coal (washed or unwashed) from Talcher coalfield transported by either all rail means or rail cum sea route.

ii) the total discounted cost of a lignite fired power plant is much lower as compard to a coalfired power plant, and

iii) the cost of power generation using Australian Coal is considerably higher.

2. The phase-1 report also analysed the various factors like the demand for energy in the region and the various supply options, availability of coal from Godavari and Talcher coalfields, transportation of coal from Talcher by rail and rail cum sea route and the port facilities.

3. Based on these factors and the economic cost of power generation, the study concluded that the lignite reserves at Neyveli should be exploited for additional power generation in the southern region to meet the shortfall in energy demand.

Phase-II study (1994-95 to 2004-05)

After careful analysis of the various factors involved, the present study (Phase-II) also concludes that there should be large scale utilisation of lignite resources at Neyveli for additional power generation in the southern region during the period 1994-95 to 2004-05. This is based on the following reasons :

4. Electricity demand and supply options

As per the electricity balance sheet drawn for the terminal years 1999-2000 and 2004-05 for the southern region there is a surplus in energy demand of 2342 MKWH but a deficit in peak load demand of 1737 MW in 1999-2000. In 2004-05 under scenario-A there is a surplus in energy demand of 11258 MkWh but a deficit of 3561 MW in peak load demand. In 2004-05 under scenario-B there is a deficit of 11016 MkWH and 6193 MW in energy demand and peak load demand respectively. Scenario A assumes an addition of 8100 MW of thermal power during the period 2000-2005 for which coal linkage is not established. This expansion to thermal capacity is difficult to achieve and hence scenario 'B' was considered. Scenario 'B' assumes an addition of 4050 MW to generating capacity from units not linked to any coalfield.

5. Coal demand and supply

The demand for coal from power stations (utilities only) increases sharply from 16.84 MT in 1989-90 to 36.01 MT in 1999-2000 and to 68.07 MT in 2004-05 which is again very optimistic. There is a very large increase of 32.06 MT in coal requirement for the period 2000-05 out of which new thermal schemes with a total generating capacity of 8100 MW and requiring 28.16 MT of coal are not linked to any coalfield.

The Godavari Coalfield which is the major coalfield supplying coal to thermal power stations in the region cannot meet the coal requirements in the terminal years of 7th, 8th, 9th and 10th plan periods. The deficit increases from 2.39 MT in 1989-90 to 5.51 MT in 1999-2000 and 11.42 MT in 2004-05. This coalfield is already linked beyond its capacity.

Talcher Coalfield which has been linked to power stations in the southern region from 8th plan onwards, is estimated to have a surplus coal availability of 6.54 MT in 1994-95. This declines to a surplus of 1.83 MT in 1999-2000 and 0.58 MT in 2004-05. Taking the two coalfields together, there will be a deficit of 3.68 MT in 1999-2000 and 10.86 MT in 2004-05. Over and above this deficit, there is a demand of 28.16 MT from new power schemes in the region which are not linked to any coalfield. So there will be heavy shortfalls in coal supplies to the region upto the period 2004-05 which will adversely affect additions to thermal capacity.

6. Lignite availability at Neyveli

Four potential blocks have been identified for mining of lignite deposits and it is projected that the lignite production capacity will increase from 14 MT in 89-90 to 32 MT in 1999-2000 and 42 MT in 2004-05. This will result in addition to thermal generating capacity by 1500 MW in the 9th plan and 1630 MW in the 10th plan periods.

7. Natural Gas :

According to the Advisory Board on Energy's report "A perspective on Energy Demand and Supply in India in 2004-05", the proved reserves of natural gas in the southern region is only 0.125 mcmd in Cauvery offshore basin. Therefore, without a proper assessment of the gas reserves in the region, it will be difficult to assess its contribution in the total supply options. However, if natural gas is available in sufficient quantities and if it is utilised for combined-cycle power generation in the region, it may prove to be economical. It will also greatly relieve the bottleneck in coal transportation.

8. Power generation through renewable sources of energy :

The cost of generating power through renewable energy technologies is at present high as compared to conventional means. Moreover their potential for the region has also not yet been fully assessed. Therefore, these resources will not contribute significantly to meet the growing energy demand in the southern region till the period 2004-05.

Recommendation :

1. The Phase-I report had recommended additional thermal power generation using lignite deposits at Neyveli as the better option for the region. Based on the analysis carried out in this study (Phase-II), it is reiterated that the potential of lignite deposits at Neyveli should be fully exploited for additional

power generation in the region upto the period 2004-05 and even beyond. It has inbuilt advantages of location, availability of water, reliability in supplies of lignite and an ever growing demand for energy in the region. On the other hand coal supplies from Talcher or other coalfields have the limitation of availability and transport network bottlenecks.

A proper assessment of the natural gas reserves in the region has to be done so that its contribution in the total power generation can be assessed.

Renewable sources of energy can not contribute significantly in meeting the growing energy demand till 2004-05 due to their high cost and lack of adequate data on their potential. Adequate data base and information should be built up on the renewable sources of energy in the region.

Annexure – 1.1

ELECTRICITY DEMAND PROJECTION

	Requirement (Billion kWh)			
	1984/85*	1994/95	1999/00	2004/05
A. CONSUMPTION				
1. Industry	72.97	185.00	280.00	367.00
2. Household	15.09	46.88	82.62	145.61
3. Agriculture	21.29	35.60	40.90	45.20
4. Transport	2.88	6.47	8.28	11.67
5. Others **	11.29	27.94	42.75	59.77
6. Total Consumption Requirement	123.52	301.89	454.55	629.25
B. NON-UTILITIES				
7. Generation	11.01	25.00	30.00	35.00
8. Auxiliary Losses	1.38	2.50	3.00	3.50
9. Net Energy Available	9.63	22.50	27.00	31.50
C. UTILITIES				
10. Consumption	113.89	279.39	427.55	597.75
11. T&D Losses (%)	21.71	20.00	19.00	18.00
12. Energy Availability Busbar	145.49	349.24	527.84	738.96
13. Auxiliary Losses (%)	7.00	7.00	7.00	7.00
14. Generation Requirement	156.44	375.53	567.57	783.83
15. Total Generation Requirement (7+14)	167.45	400.53	597.57	818.83

* Provisional

** Others include public lighting, public water works and Sewerage, Commercial dn Miscellaneous uses.

Source : 1. CEA for 1984/85 consumption data for electricity.

2. Report of the Energy Demand Screening Group (August 1986) – Planning Commission.

Annexure - 2.1/1

OPTIMAL GENERATION EXPANSION PLAN
ADDITIONS TO INSTALLED GENERATING CAPACITY STATIONWISE
(1985-2000A.D.)

SOUTHERN REGION SR(01)

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW) 7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
	HYDRO PROJECTS				
	A. SANCTIONED PROJECTS:				
	ANDHRA PRADESH				
1.	Balimela	2x30	60		
2.	Nagarjuna Sagar II	3x100	100		
3.	Srisailam II	3x110	330		
4.	Upper Sileru	2x60		120	
5.	Penna Ahobilam	2x10	20		
6.	Nagarjunasagar LBC	2x30	60		
7.	Pochampad	3x9	27		
8.	Nagarjunasagar RBC	1x30	30		
	Sub-total:		627	120	
	KARNATAKA				
1.	Varahi	2x115+2x4.5	239		
2.	Supa Dam	2x50	100		
3.	Ghatprabha	2x16	32		
4.	Gangawali	2x105			210
5.	Kalinadi St.II	2x25+2x32+ +4X25		114	164
6.	Shivpur	2x9		18	
	Sub-total:		371	132	374
	KERALA				
1.	Idmalayar	2x37.5	75		
2.	Kakkad	2x25	50		
3.	Idukki II	3x130	390		
4.	Kallada	2x7.5	15		
5.	Lower Pariyar	3x60		180	
	Sub-total:		530	180	

Annexure - 2.1/2

Cont.SR(02)

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW)		
			7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
	TAMIL NADU				
1.	Servalar	1x20	20		
2.	Kadamparai	4x100	400		
3.	Kundah V	1x20	20		
4.	Kundah V Ext.	1x30		30	
5.	Lower Mettur	8x15	120		
	Sub-total:		560	30	
	Total sanctioned (Hydro):		2116*	466*	374

* including benefits of 28.25 MW during 7th Plan and 4.5 MW during 8th Plan periods from small hydro schemes.

B. CEA CLEARED SCHEMES

Sl. No.	Name of the Project	I.C. (MW)	7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
	ANDHRA PRADESH				
1.	Srisailam L.B.P.H.	9x110		990	
	Sub-total:			990	
	KARNATAKA				
1.	Sharavati Tail Race	4x60		240	
	Sub-total:			240	
	KERALA				
1.	Puyankutty	2x120		240	
2.	Muvattapuzha Valley	1x6		6	
	Sub-total:			246	
	Total CEA cleared (Hydro):		1.5*	1487*	

* including benefits of 1.5 MW during 7th Plan and 10.9 MW during 8th Plan periods from small hydro schemes.

Annexure - 2.1/

Cont.SR(03)

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW) 7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
C. NEW SCHEMES					
ANDHRA PRADESH					
1.	Polavaram	720			720
2.	K.C. Canal	60			60
3.	Lower Machkund	120			120
4.	Jalaput	18		18	
5.	Inchempali	660			660
6.	Jurala	221			221
7.	Pulichintla	60			60
8.	Putalgudam	50			50
	Sub-total:			18	1891
KARNATAKA					
1.	Kabini	20			20
2.	U. Krishna	268		150	118
3.	Sonda	210			210
4.	Kalinadi St.III	300			300
5.	Aghnashini	315			315
6.	Barapole	180			180
7.	Cauvery Development	400			400
8.	Netravati	228			228
9.	Mahadayi	200			200
	Sub-total:			150	1971
KERALA					
1.	Pallivasal Rep.	240			240
2.	Chalakudy	200		100	100
3.	Pandiar Punna	70			70
4.	Manathawady	240			240
5.	Parinjak ty	240			240
	Sub-total:			100	890

Annexure - 2.1/4

Cont.SR(04)

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW)		
			7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
TAMIL NADU					
1.	Pykara Ultimate	100		100	
2.	Upper Amravati	30			30
3.	Shanmukha Nadi	30			30
4.	Nellithorai	50			50
5.	Kundah Ultimate	160			160
6.	Upper Pandiyar	40			40
7.	Lower Moyar	40			40
8.	Paralyar	25		25	
9.	Sathanur Dam	20		20	
10.	Bhavani Kattalai Barrage	90			90
	Sub-total:	585		145	440
	Total New (Hydro):			413	5192

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW) 7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
THERMAL PROJECTS					
A. SANCTIONED PROJECTS:					
ANDHRA PRADESH					
1.	Vijayawada	2x210	210	210	
	Sub-total:		210	210	
KARNATAKA					
1.	Raichur	2x210	210		
2.	Raichur Ext.	1x210		210	
	Sub-total:		210	210	
TAMIL NADU					
1.	Mettur	2x210	420		
2.	Mettur Ext	2x210	210	210	
3.	North Madras	3x210		630	
4.	Tuticorin Ext.	2x210	210	210	
	Sub-total:		840	1050	
CENTRAL SECTOR					
1.	Ramagundam STPS	3x200+1x500	500		
2.	Ramagundam St.II	2x500	500	500	
3.	Neyveli 2nd M.Cut	3x210	630		
4.	Neyveli 2nd M.Cut Ext.	4x210	210	630	
	Sub-total:		1840	1130	
	Total sanctioned(Thermal):		3100	2600	
B. CEA CLEARED SCHEMES					
KARNATAKA					
1.	Gas turbines	4x30	120		
	Sub-total:		120		

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW) 7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
TAMIL NADU					
1.	Basin Bridge.(Gas)	3x30	120		
	Sub-total:		120		
	Total CEA cleared (Thermal):		318*		

* including benefits of 77.8 MW during 7th Plan period from small thermal schemes.

C. NEW PROJECTS

Sl. No.	Name of the Project	I.C. (MW)	7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
ANDHRA PRADESH					
1.	Madanur(Rayal-Seema Region)	4x500			2000
2.	Vijayawada-5	1x500		500	
	Sub-total:			500	2000
KARNATAKA					
1.	Raichur-unit 5	1x500		500	
2.	Mangalore(Costal)	2x210+2x500		420	1000
	Sub-total:			920	1000
KERALA					
1.	Cochin	3x210		630	
	Sub-total:			630	
TAMIL NADU					
1.	North Madras Extn.	2x210		420	
2.	Cuddalore(Coastal)	4x500			2000
3.	Kanyakumari(Coastal)	1x500			500
	Sub-total:			420	2500

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW) 7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
1.	Neyveli-3rd M.C.	3x500		1500	
2.	Neyveli-4th M.C.	3x500			1500
3.	Manguru STPS	4x500		1000	1000
	Sub-total:			2500	2500
	Total New (Thermal):			4970	8000

Annexure - 2.1/8

Cont.SR(08)

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW) 7th Plan (1985-90)	 8th Plan (1990-95)	 9th Plan (1995-2000)
NUCLEAR PROJECTS					
A. SANCTIONED PROJECTS:					
1.	M.A.P.P.	2x235	235		
	Sub-total sanctioned (Nuclear):		235		
C. NEW SCHEMES					
1.	Kaiga	2x235		470	
2.	NU-235	2x235		470	
3.	New-500	2x500		500	500
4.	New-500	2x500			1000
	Sub-total New (Nuclear):			1440	1500
	Total (Nuclear):		235	1440	1500

Annexure - 2.2/1

FEASIBLE-CUM-DESIRABLE GENERATION EXPANSION PLAN
ADDITIONS TO INSTALLED GENERATING CAPACITY STATIONWISE
(1985-2000A.D.)

SOUTHERN REGION **SR-(D1)**

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW)		
			7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
HYDRO PROJECTS					
A. SANCTIONED PROJECTS:					
ANDHRA PRADESH					
1.	Balimela	2x30	60		
2.	Nagarjuna Sagar II	3x100	100		
3.	Srisailam II	3x110	330		
4.	Upper Sileru	2x60		120	
5.	Penna Ahobilam	2x10	20		
6.	Nagarjunasagar LBC	2x30	60		
7.	Pochampad	3x9	27		
8.	Nagarjunasagar RBC	1x30	30		
	Sub-total:		**627**	**120**	
KARNATAKA					
1.	Varahi	2x115+2x4.5	239		
2.	Supa Dam	2x50	100		
3.	Ghatprabha	2x16	32		
4.	Gangawali	2x105			210
5.	Kalinadi St.II	2x25+2x32+ +4X25		114	164
6.	Shivpur	2x9		18	
	Sub-total:		**371**	**132**	**374**
KERALA					
1.	Idmalayar	2x37.5	75		
2.	Kakkad	2x25	50		
3.	Idukki II	3x130	390		
4.	Kallada	2x7.5	15		
5.	Lower Pariyar	3x60		180	
	Sub-total:		**530**	**180**	

Annexure - 2.2/2
Cont.SR(D2)

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW)		
			7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
TAMIL NADU					
1.	Servalar	1x20	20		
2.	Kadamparai	4x100	400		
3.	Kundah V	1x20	20		
4.	Kundah V Ext.	1x30		30	
5.	Lower Mettur	8x15	120		
	Sub-total:		**560**	**30**	
	Total Sanctioned (Hydro):		**2116***	**467***	**374**

* including benefits of 28.25 MW during 7th Plan and 4.5 MW during 8th Plan periods from small hydro schemes.

B. CEA CLEARED SCHEMES

Sl. No.	Name of the Project	I.C. (MW)	7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
ANDHRA PRADESH					
1.	Srisailam L.B.P.H.	9x110		990	
	Sub-total:			**990**	
KARNATAKA					
1.	Sharavati Tail Race	4x60		240	
	Sub-total:			**240**	
KERALA					
1.	Puyankutty	2x120		240	
2.	Muvattapuzha Valley	1x6		6	
	Sub-total:			**246**	
	Total CEA Cleared(Hydro)		**1.5***	**1487***	

* including benefits of 1.5 MW during 7th Plan and 10.9 MW during 8th Plan periods from small hydro schemes.

Annexure - 2.2/3
Cont.SR(D3)

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW) 7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
C. NEW SCHEMES					
ANDHRA PRADESH					
1.	Polavaram	720			360
2.	K.C. Canal	60			60
3.	Lower Machkund	120			120
4.	Jalaput	18		18	
5.	Inchempali	660			330
6.	Jurala	221			221
7.	Pulichintla	60			60
8.	Putalgudam	50			50
	Sub-total:			**18**	**1201**
KARNATAKA					
1.	Kabini	20			20
2.	U. Krishna	268		150	118
3.	Sonda	210			210
4.	Kalinadi St.III	300			300
5.	Aghnashini	315			315
6.	Barapole	180			180
7.	Cauvery Development	400			400
8.	Netravati	228			228
9.	Mahadayi	200			200
	Sub-total:			**150**	**1971**
KERALA					
1.	Palivasal Rep.	240			240
2.	Chalakudy	200		100	100
3.	Pandiar Punna	70			70
4.	Manathawady	240			240
5.	Parinjakatty	240			240
	Sub-total:	**990**		**100**	**890**
TAMIL NADU					
1.	Pykara Ultimate	100		100	
2.	Upper Amravati	30			30
3.	Shanmukha Nandi	30			30
4.	Nellithoriai	50			50
5.	Kundah Ultimate	160			160
6.	Upper Pandiyar	40			40

Annexure - 2.2/4

Cont.SR(D4)

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW)		
			7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
7.	Lower Moyar	40			40
8.	Paralyar	25		25	
9.	Sathanur Dam	20		20	
10.	Bhavani Kattalai	90			90
	Sub-total:	**585**		**145**	**440**
	Total New (Hydro):			**413**	**4502**

Annexure - 2.2/5
Cont.SR(D5)

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW) 7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
THERMAL PROJECTS					
A. SANCTIONED PROJECTS:					
ANDHRA PRADESH					
1.	Vijayawada	2x210	210	210	
	Sub-total:		210	210	
KARNATAKA					
1.	Raichur	2x210	210		
2.	Raichur Ext	1x210		210	
	Sub-total:		**210**	**210**	
TAMIL NADU					
1.	Mettur	2x210	420		
2.	Mettur Ext	2x210	210	210	
3.	North Madras	3x210		630	
4.	Tuticorin Ext	2x210	210	210	
	Sub-total:		**840**	**1050**	
CENTRAL SECTOR					
1.	Ramagundam STPS	3x200+1x500	500		
2.	Ramagundam St.-II	2x500	500	500	
3.	Neyveli 2nd M.Cut	3x210	630		
4.	Neyveli 2nd M.Cut Ext.	4x210	210	630	
	Sub-total:		1840	1130	
	Total sanctioned (Thermal)		3100	2600	

Annexure - 2.2/6
Cont.SR(D6)

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW)		
			7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
B. CEA CLEARED SCHEMES					
KARNATAKA					
1.	Gas turbines	4x30	120		
	Sub-total:		**120**		
TAMIL NADU					
1.	Basin Bridge.(Gas)	3x30	120		
	Sub-total:		**120**		
	Total CEA cleared (Thermal)		**318***		

* including benefits of 77.8 MW during 7th Plan period from small thermal schemes.

Sl. No.	Name of the Project	I.C. (MW)	7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
C. NEW PROJECTS					
ANDHRA PRADESH					
1.	Madanur (Rayal-Seema Region)	2x210+1x500		420	500
2.	Vijayawada-5	1x500		500	
3.	Kalingapatnam (Coastal)	2x500		500	500
	Sub-total:			**1420**	**1000**
KARNATAKA					
1.	Raichur-unit 5	1x500		500	
2.	Mangalore(Costal)	2x210+2x500		420	1000
	Sub-total:			**920**	**1000**
KERALA					
1.	Kayakulam(Coastal)	3x210		630	
2.	New TPS (Coastal)	3x210			630
	Sub-total:			**630**	**630**

Annexure - 2.2/7

Cont.SR(D7)

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW)		
			7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
TAMIL NADU					
1.	North Madras	2x210+2x500		420	1000
2.	St.II&III Ext.				
3.	Cuddalore(Coastal)	5x210		420	630
4.	Kanyakumari(Costal)	2x500			1000
	Sub-total:			**840**	**2630**
PONDICHERRY					
1.	Pondicherry(Coastal)	2x210			420
	Sub-total:				**420**
CENTRAL SECTOR					
1.	Neyveli-2nd M.C.Ext	4x210		420	420
2.	Neyveli - 3rd M.C.	3x500		500	1000
3.	Neyveli - 4th M.C.	3x500			500
4.	Manguru STPS	4x500		1000	1000
5.	New STPS - (Coastal)	2x500			1000
	Sub-total:			**1920**	**3920**
	Total New (Thermal):			**5730**	**9600**

Annexure - 2.2/8

Cont.SR(D8)

Sl. No.	Name of the Project	I.C. (MW)	Capacity Benefits During (MW)		
			7th Plan (1985-90)	8th Plan (1990-95)	9th Plan (1995-2000)
NUCLEAR PROJECTS					
A. SANCTIONED PROJECTS:					
1.	M.A.P.P.	2x235	235		
	Sub-total sanctioned (Nuclear)		235		
C. NEW SCHEMES					
1.	Kaiga	2x235		470	
2.	NU-235	2x235			470
3.	New-500	2x500			500
	Sub-total New (Nuclear)			470	970
	Total (Nuclear)		235	470	970

Annexure - 3.1/1

Thermal Power Stations & Coal Requirement in the Southern Region

Sl. No.	Name	State	Total Capacity (mW)	Coal Requirement (MT) 1994-95	1999-2000	Beyond 2000	Status	Linkage
1.	Ramagundam STPS (Central)	AP	600	2.12	2.12	2.12	Existing	Godavari
2.	Kothagudam	AP	680	2.90	2.90	2.90	Existing	Gadavari
3.	Ramagundam	AP	62.5	0.27	0.27	0.27	Existing	Godavari
4.	Vijayawada	AP	420	1.83	1.83	1.83	Existing	Godavari
5.	Nellore	AP	30	0.09	0.09	0.09	Existing	Godavari
6.	Vijayawada (Unit 3&4)	AP	420	1.50	1.50	1.50	On going	Godavari
7.	Ramagundam STPS (Unit 4, 5 & 6)	AP	1500	4.71	4.71	4.71	On going	Godavari
8.	Mudannur (Unit 1 & 2)	AP	420	1.50	1.50	1.50	New	Godavari
*9.	Kalingapatnam	AP	1000	-	-	3.48	New	Not Linked
10.	Vijayawada (Unit 5)	AP	500	-	-	1.95	New	Not Linked
11.	Mudannur (unit 3)	AP	500	-	-	1.95	New	Not Linked
12.	Manuguru STPS	AP	2000	-	3.90	7.80	New	Godavari
13.	Raichur	Karnataka	420	1.51	1.51	1.51	Existing	Godavari
14.	Raichur (Unit 3)	""	210	0.75	0.75	0.75	On going	Godavari
15.	Raichur (Unit 4)	""	210	0.75	0.75	0.75	On going	Godavari
*16.	Mangalore (Unit 1,2)	""	420	1.25	1.34	1.34	New	Talcher
17.	Raichur (Unit 5,6)	""	420	-	-	1.50	New	Not Linked
*18.	Mangalore (Unit 3,4)	""	1000	-	-	3.48	New	Not Linked
			10812.5	19.18	23.17	39.43		

(Contd /....)

Annexure - 3.1/2

Sl. No.	Name	State	Total Capacity (mW)	Coal Requirement (MT) 1994-95	1999-2000	Beyond 2000	Status	Linkage
*19.	Kayakulam	Kerala	420	0.99	1.34	1.34	New	Talcher
*20.	New TPS	Kerala	630	-	-	2.01	New	Not Linked
*21.	Pondicherry	Pondicherry	420	-	-	1.34	New	Not Linked
*22.	New TPS (Central)	Not known	1000	-	-	3.48	New	Not Linked
23.	Ennore	Tamil Nadu	450	1.62	1.62	1.62	Existing	Godavari
*24.	Tuticorin	Tamil Nadu	630	2.27	2.27	2.27	Existing	Ramganj
*25.	Tuticorin Ext (Unit 4,5)	Tamil Nadu	420	1.34	1.34	1.34	On going	Talcher
26.	Mettur	Tamil Nadu	630	2.25	2.25	2.25	On going	Godavari
*27.	North Madras	Tamil Nadu	630	2.01	2.01	2.01	On going	Talcher
28.	Mettur Ext.	Tamil Nadu	210	0.67	0.67	0.67	On going	Godavari
*29.	North Madras (Unit 4,5)	Tamil Nadu	420	-	1.34	1.34	New	Talcher
*30.	North Madras (Unit 6,7)	Tamil Nadu	1000	-	-	3.48	New	Not Linked
*31.	Cuddalore	Tamil Nadu	630	-	-	2.01	New	Not Linked
*32.	Kanyakumari	""	1000	-	-	3.48	New	Not Linked
	TOTAL		19302.5	30.33	36.01	68.07		

* Coastal Stations.

Source : Department of Coal paper (July 1987).

Annexure - 3.2

Coalfield wise Non-coking coal demand and availability in 1994-95 and 1999-2000 (Million Tonnes).

Coalfield	1994-95 Demand Utilities	1994-95 Demand Others	Total	Production	Deficit/ Surplus	1999-2000 Demand (Utilities only)	1999-2000 Production
1. Makum	0.08	1.08	1.16	2.00	(+)0.84	4.28	3.90
2. Raniganj	15.67	16.80	32.47	29.80	(-)2.67	19.25	45.44
3. Mugma-Salanpur	4.92	3.29	8.21	2.90	(-)5.31	4.92	3.62
4. Rajmahal	11.42	0.10	11.52	10.50	(-)1.02	17.1[illegible]	13.50
5. Jharia	7.76	5.70	13.46	9.81	(-)3.65	7.76	6.41
6. Giridih	0.47	0.22	0.69	0.72	(+)0.03		-
7. E&W Bokaro	4.74	3.00	7.74	6.24	(-)1.50	6.24	7.64
8. South Karanpura	0.85	4.80	5.65	6.67	(+)1.02	0.85	8.42
9. North Karanpura	16.21	3.25	19.46	18.84	(-)0.62	26.49	34.67
10. Singrauli	33.06	2.28	35.34	43.00	(+)7.66	49.83	64.10
11. Patherkhera	2.58	0.05	2.63	2.78	(+)0.15	2.58	3.68
12. Pench-kanhan	1.79	1.39	3.18	2.83	(-)0.35	1.79	2.83
13. Umrer	1.58	0.02	1.60	1.84	(+)0.24	1.58	1.84
14. Kamptee Siliwara	5.05	0.35	5.40	5.40	-	5.05	4.88
15. Wardha Valley	14.28	5.89	20.17	15.77	(-)4.40	20.65	21.77
16. Central India	7.42	15.54	22.96	19.59	(-)3.37	8.98	18.75
17. Korba	18.77	3.86	22.63	24.82	(+)2.19	23.94	29.80
18. Ib Valley	10.91	3.81	14.72	15.45	(+)0.73	20.81	21.50
19. Talcher	9.53	8.07	17.60	24.14	(+)6.54	20.15	30.84
20. Godavari	24.80	10.79	35.59	32.00	(-)3.59	30.26	38.00

Notes : 1. For 1994-95 there are some variation in the demand projection as compared to the figures given in phase-1 report. The variance is due to revision of demand carried out by department of coal.

2. For 1999-2000, demand assessment for other sectors including captive power is not available.

Source : Department of coal paper (July 1987).

Annexure - 3.3

GODAVARI VALLEY COALFIELD - PRODUCTION PLAN

	PRODUCTION (MT)		
	1989-90	INDICATIVE 1994-95	1999-2000
1) EXISTING MINES	11.29	9.92	8.50
2) SANCTIONED PROJECTS	9.41	10.90	10.60
3) NEW PROJECTS	3.30	11.18	18.90
TOTAL	24.00	32.00	38.00

Details of New Projects

1. RK - 7A	0.23	0.85	1.00
2. RK 6 & 7	0.12	0.30	0.64
3. OC-II Rgm	1.00	2.00	2.00
4. OC-III Mng	0.30	0.42	0.42
5. OC-III Rgm	0.75	2.50	2.50
6. Kakatya 1x1A	0.02	0.02	0.30
7. Goleti 1 & 2 Reconst	0.34	0.85	1.00
8. Khairagura O/C	0.10	0.45	0.50
9. Medapalli O/C	0.24	1.10	1.25
10. R.K. 1 & 2 longwall	0.20	0.85	0.85
11. Chinnuvr 1 & 2	-	0.25	0.50
12. Gautam Khani O/C	-	0.50	2.00
13. Shaft Block-I Rgm	-	0.30	1.50
14. Cherla O/C	-	0.20	0.50
15. Kakatya 2x2A	-	0.15	0.50
16. Dorli Block	-	0.11	0.50
17. Srirampur 3x3 longwall	-	0.10	0.44
18. Shaft Block II Rgm	-	-	
19. Khairagura U/G Mine		-	
20. K.K. 2 A Longwall		-	2.50
21. Rk-5 Shaft Block		-	
TOTAL	3.30	11.18	18.90

Annexure - 3.4

TALCHER COALFIELD - PRODUCTION PLAN

	PRODUCTION (MT)		
	1989-90	1994-95	1999-2000
1) EXISTING MINES	1.44	1.44	1.44
2) SANCTIONED PROJECTS	4.70	5.05	5.05
3) NEW PROJECTS	1.86	17.65	24.35
TOTAL	8.00	24.14	30.84

Details of New Projects

1. Nandira longwall	0.36	0.65	0.85
2. Kalinga O/C	1.05	6.00	8.00
3. Ananta O/C	0.45	4.00	4.50
4. Lingraj O/C	-	4.00	5.00
5. Gopalprasad O/C	-	2.50	5.00
6. Ananta U/G	-	0.50	1.00
TOTAL	1.86	17.65	24.35